

JPL SPECIFICATION DOCUMENT D-18189 VERSION A

WIDE FIELD CAMERA-3 (WFC3)

OPTICAL FILTERS

APPROVALS

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1 **SCOPE**

This specification establishes the detailed requirements for the fabrication and testing of the optical filters for the ultraviolet-visible (UVIS) camera used in the *Hubble Space Telescope* Wide Field Camera-3 (WFC3).

The following is the scope of work specified by this document:

- A. The WFC3 instrument requires a set of 48 optical filters for the UVIS camera, as specified in this document. The filters fall into the following four functional categories: single passband filters, quad passband filters, dispersive (grism, prism) filters, and calibration elements.
- B. The fabrication of a subset of these 48 filters will be contracted to each selected vendor. For each filter, the vendor shall deliver the following: two (2) flight candidate filters of each filter type, relevant test results in electronic form (ASCII or Excel), and relevant manufacturing data as specified in Appendix C.
- C. In order to monitor progress, the JPL cognizant engineer will request technical interchange meetings to be held when appropriate at the vendor's manufacturing site, as well as a monthly status telecon.

2 **REQUIREMENTS**

2.1 ***WFC3 DOCUMENTS***

Spectral characteristics of the individual filters are specified in tabular form in Appendix A. Specification that are common to more than one filter are specified in this document and the following applicable documents.

In case of conflict between the requirements of this specification and the requirements of any document referenced herein, the conflict shall be referred to the JPL cognizant engineer for resolution.

2.1.1 ***JPL OPTICAL FILTER DRAWINGS***

10195731	Filter Substrate
10195732	Filter Assembly
10195733	Quad Filter
10195734	Grating (Grism) Filter

2.1.2 JPL DOCUMENTS

FS515279A	Cleaning, Handling, and Storage Requirements, Optical Filters, Wide Field and Planetary Camera II, Flight Equipment
FD500451	JPL Ink Marking SPEC
751-23	WFPC Environmental Requirements Document (for reference)
751-38	WFPC Contamination Control Plan (for reference)

2.1.3 MILITARY SPEC DOCUMENTS

MIL-G-174	Glass, Optical
MIL-M-13508	Mirror, Front Surface Aluminized for Optical Elements
MIL-O-13830	Optical Components for Fire Control Instrument, General Specification Governing the Manufacture, Assembly, and Inspection of

2.2 DEPOSITION PROCESS

Oxide dielectrics and ion-beam-assisted deposition are preferred, for all appropriate filters, to provide the best available long-term stability and durability of the filters. In the case of filters for which ion-assisted oxide coatings are inappropriate, then an alternative deposition process shall be specified that provides the best available long-term stability and durability.

2.3 SUBSTRATE CONFIGURATION

The vendor shall specify either monolithic or laminated filter substrate configurations as appropriate to meet the passband and blocking spectral requirements and the transmitted wavefront requirements. Laminated and monolithic filters are referred to as “Type A” and “Type C” respectively in the filter drawings, and the applicable filter configuration shall be tabulated as indicated in Appendix C.

2.4 SUBSTRATE MATERIALS

The vendor shall make the selection of the substrate materials for each filter. The selected substrate material for each filter shall be tabulated as indicated in Appendix C and reported to the JPL cognizant engineer prior to finalizing the individual filter designs.

The substrate refractive indices shall be known with an accuracy of ± 0.005 . When available, the vendor shall provide the glass melt data. The refractive indices of the substrate materials shall be tabulated in Appendix C.

2.5 SPECTRAL REQUIREMENTS

Appendix A lists the filters spectral performance. All wavelengths are specified in Ångstroms. The following data are tabulated in the spectral performance table:

- A. Each filter is identified by its descriptive **filter name** (e.g. F555W) and its sequential **filter number** (e.g. UVIS 7).
- B. λ_{-90} and λ_{+90} are the wavelengths between which the transmittance is everywhere greater than 90% of peak.
- C. λ_{-50} and λ_{+50} are the wavelengths on either side of the passband where the transmittance equals 50% of peak and remains less than 50% of the peak for all wavelengths shortward of λ_{-50} and longward of λ_{+50} respectively.
- D. λ_{-01} and λ_{+01} are the wavelengths on either side of the central wavelength at which the transmittance is less than 1% absolute and remains below 1% for all wavelengths shortward of λ_{-01} and longward of λ_{+01} , respectively.
- E. The full width at half-maximum transmittance $FWHM = [\lambda_{+50} - \lambda_{-50}]$.
- F. The central wavelength of the passband $\lambda_0 = [\lambda_{-50} \times \lambda_{+50}]^{1/2}$.
- G. **Min average T ($\lambda_{-90}:\lambda_{+90}$):** The minimum acceptable value for the absolute transmittance averaged over the wavelength range from λ_{-90} to λ_{+90} .

2.5.1 WAVELENGTH TOLERANCES

Tolerance criteria are called out for the most critical wavelength characteristics of each filter. In general, for all filters other than the narrowband filters, the critical characteristic wavelengths are λ_{-50} and λ_{+50} , which shall be met with a tolerance of ± 5 Ångstroms. For the narrowband filters (all those for which λ_{-50} and λ_{+50} are unspecified in Appendix A), the critical characteristic wavelengths are λ_{-90} and λ_{+90} , which shall be met with a tolerance of ± 1 Ångstrom. Special requirements, enclosed in [square brackets] in Appendix A, shall be met with a tolerance of ± 1 Ångstrom. Those tabular entries identified with an asterisk (*) are determined by the properties of the specified color glass.

2.5.2 OUT-OF-BAND REJECTION LONGWARD OF THE PASSBAND

Out-of-band transmittance at wavelengths longward of λ_{+01} is to be minimized. The maximum acceptable transmittances longward of λ_{+01} are given in Appendix A, as follows.

Out of Band, Max T @ λ : the out-of-band transmittance shall be less than the tabulated absolute upper limit at all wavelengths longward of the tabulated wavelength. In some cases, the out-of-band transmittance is specified stepwise at two or three wavelengths.

2.5.3 OUT-OF-BAND REJECTION SHORTWARD OF THE PASSBAND

Out-of-band transmittance at wavelengths shortward of λ_{-01} is to be minimized. For all but the narrowband filters, the absolute transmittance at wavelengths shortward of the filter passband shall be less than 10^{-6} at all wavelengths shortward of λ_{-01} by a wavelength shift equal to the FWHM, i.e. at wavelengths $\lambda < [\lambda_{-01} - \lambda_{+50} + \lambda_{-50}]$. For the narrowband filters (for which λ_{-50} and λ_{+50} , are unspecified in Appendix A), the absolute transmittance at wavelengths shortward of the filter passband shall be less than 10^{-6} at all wavelengths $\lambda < [2 \times \lambda_{-01} - \lambda_{+01}]$.

2.5.4 RIPPLES IN THE λ_{-90} TO λ_{+90} REGION

Transmittance ripples within the 90% passband shall be such that the transmittance nowhere falls below 90% of the peak transmittance.

2.5.5 ANGLE OF INCIDENCE (AOI)

The filter specifications shall be met for a normal angle of incidence in an F/31 beam.

2.5.6 ANTIREFLECTION COATINGS

All filters shall have antireflection (AR) coatings on each outer surface that is not used for a passband defining coating. The reflectance of each AR coated surface shall be less than 1.0% surface between λ_{-01} and λ_{+01} .

2.5.7 OPERATIONAL TEMPERATURE

The filters shall meet the spectral requirements in Appendix A at the operational temperature of 0°C.

2.6 DIMENSIONS

2.6.1 OVERALL DIMENSIONS

Overall dimensions and tolerances of the filters, except thickness, are specified on the filter substrate drawing. Overall dimensions of the gratings, including thickness, are specified on the grating filter drawing.

2.6.2 CLEAR APERTURE

The clear apertures of the filters and gratings are specified on the applicable drawings. All passband defining and blocking coatings shall extend to within 0.025 inch of the edge of the filter.

2.6.3 FOCUS SHIFT AND FILTER THICKNESS

The filters shall be parfocal. The thickness of each filter substrate shall be determined by the vendor, subject to the requirement of parfocality as expressed in the following equation:

$$\text{Focus shift} = \frac{(n_1 - 1)}{n_1} t_1 + \frac{(n_2 - 1)}{n_2} t_2 + \dots + \frac{(n_{fs} - 1)}{n_{fs}} \times 10.922 \text{ mm} = 5.151 \text{ mm}.$$

This equation adds together the focus shifts of each plano/plano element of the optical filter ($k=1,2,\dots$ as appropriate, where t_k is the thickness and n_k the refractive index of element k at the filter's central wavelength λ_0) plus the additional focus shifts of two optical windows in the UVIS CCD optical path. For this purpose, the focus shift of each filter shall equal the focus shift of a 5.500 mm thick plano/plano fused silica substrate at a wavelength of 633 nm (refractive index of 1.457) plus the shift of two fused silica CCD windows (with refractive index n_{fs} and thicknesses of 8.382 and 2.540 mm respectively).

The focus shift equation shall be evaluated with the refractive index of the substrate (glass melt data if available) and bonding materials measured at λ_0 . The substrate thickness of each filter element shall be reported to the JPL cognizant engineer prior to finalizing the individual filter design, and tabulated as indicated in Appendix C. The manufactured filters shall conform to the specified parfocal total filter thickness within a tolerance of ± 0.100 mm.

2.6.4 WEDGE

The allowable wedge for individual substrates and the overall filter are specified in the substrate drawing (0.0006 inch wedge across 2.256 inch aperture). The vendor is responsible for providing the measurement of the wedge angle and for reporting the test results to JPL prior to the filter coating process.

2.7 OPTICAL QUALITY

2.7.1 SURFACE FIGURE

The optical figure of each filter surface shall be either plano or spherical, as specified for the individual filters in Appendix C.

2.7.2 TRANSMITTED WAVEFRONT

For laminated filters the wavefront accuracy is specified in Note 4 of the drawing and applies to the completed filter rather than to the individual substrates. For the single substrate filters the wavefront accuracy is specified in Note 11 of the drawing. The wavefront accuracy is defined as a fraction of a wave at 633 nm, although it will be verified by test at the central wavelength λ_0 of the filter.

2.7.3 SCRATCH AND DIG

Scratch and dig, and surface roughness of the filter substrates are specified on the substrate and grating drawings.

2.7.4 COATING QUALITY

These requirements are applicable to the filter bandpass elements, out-of-band blocking elements, and anti-reflection coatings:

2.7.4.1 ADHESION: *The coating shall exhibit no loss of adhesion when subjected to the tape test defined in paragraph 4.4.6 of MIL-M-13508.*

2.7.4.2 HARDNESS: *The coating shall show no signs of deterioration such as streaks or hairline scratches after being subjected to the cheesecloth test as defined in paragraph 4.4.5 of MIL-M-13508.*

2.7.4.3 VISUAL QUALITY: *The thin film coatings shall exhibit no structural non-uniformity, streaks, or scratches larger than 40–20 per MIL-0-1380 when inspected with the unaided eye.*

2.7.4.4 HUMIDITY: *There shall be no visible evidence of coating deterioration or evidence of corrosion or pitting to the filter after exposure to an atmosphere with a relative humidity greater than 95% at 5°C for 24 hours and for 50°C for 24 hours.*

2.7.5 ADHESIVE BONDLINE

If adhesive is used in the construction of any filter, then bubbles, voids, blisters, and dirt (lint or dust) shall not exceed the limits of digs and bubbles specified for optical surface quality on the filter substrate drawing. Edge defects in the adhesive shall not extend more than 0.02 inch from the edge of the filter.

2.7.6 BIREFRINGENCE

The filters shall show no evidence of birefringence when inspected at normal incidence through crossed polarizers. Crystalline substrates shall show no evidence of multi-crystals when inspected through crossed polarizers.

2.7.7 SCATTERED LIGHT

The light scattered on transmission by the filters shall not exceed a Bidirectional Transmission Distribution Function (BTDF) value of 1.0/sr at a deviation angle of 0.5 degrees. By definition,

$BTDF = \frac{\partial P_s / \partial \Omega_s}{P_i}$, where P_i is the incident flux per unit surface area at normal incidence, and $\partial P_s / \partial \Omega_s$ is the scattered flux per unit surface area per steradian at a given deviation angle.

2.8 MATERIALS AND PROCESSES

2.8.1 UNIFORMITY OF PROCESSING

The manufacturing process for all copies of any filter must be as uniform as possible. The manufacturing process (temperature, humidity, bake time, interval between coating and lamination) must be carefully monitored and documented so that copies with the most similar processing histories can be identified.

2.8.2 COATING MATERIALS

The coating materials shall be capable of surviving the environmental conditions specified herein without damage.

2.8.3 OPTICAL ADHESIVE

Adhesives used in the construction of any laminated filters must be approved in advance by the JPL cognizant engineer. The following epoxies have generally proven satisfactory: Epo-Tek 301, Epo-Tek UV, and Ecobond 24.

2.8.4 EDGE SEALANT MATERIALS

Materials used to seal the edges of laminated filters require approval of the JPL Cognizant Engineer. The use of edge sealant materials is optional.

2.9 ENVIRONMENTAL REQUIREMENTS

- **Acceptance Test Environment**

Temperature:	20 ±5°C
Humidity:	< 40% RH

- **Storage Environment**

Temperature:	-20°C to +40°C
Humidity:	< 40% RH

- **Launch Environment (non-operating)**

Temperature:	-20°C to +40°C
Pressure:	15 psi to < 10 ⁻⁶ Torr
Pressure change:	Specified range above in 15 min
Humidity:	0 to 50% RH
Vibration:	7.9 G rms overall, as follows.
	+ 5 dB/octave over 20–80 Hz
	0.15 G ² /Hz over 80–250 Hz
	-6 dB/octave over 250–2000 Hz

- ***In-Orbit Environment***

Operating temperature:	0 ± 5 °C
Survival temperature range	-20°C to +40°C
Pressure:	$< 10^{-6}$ Torr
Particle radiation:	5×10^3 rad (Si) total dose

3 QUALITY ASSURANCE

3.1 TESTING

The filter vendor shall be responsible to carry out any filter or materials tests necessary to assure conformity to the requirements of Section 2 of this document. Records of all tests shall be maintained, and a copy of these records shall be delivered to JPL along with the hardware.

JPL shall carry out acceptance tests on each delivered flight candidate filter. These tests will include the following:

- Filter name and S/N
- Spectral passband and blocking performance.
- Transmitted optical wavefront uniformity.
- Focus shift.
- Filter dimensions (clear aperture, thickness, wedge, radii of curvature).
- Visual inspection of substrates, surface polish, coatings, and adhesive bond lines.
- Optical scatter and surface roughness.

Acceptance of the filters shall be performed by JPL according to the test matrix in Appendix B. These tests will determine if the filters meet the requirements as detailed specifications in Section 2.

3.2 FILTER NUMBERING SYSTEM AND DESIGNATIONS

Each delivered filter shall be marked with an identifying part number consisting of the applicable filter name and a three-digit serial number (e.g. "F555W-001").

3.3 CERTIFICATION AND TRACEABILITY

All materials and associated processes shall be certified as having met the requirements of the applicable controlling documents. All materials shall be identified with a material lot number. Traceability of materials in a serialized assembly or subassembly shall be provided by identifying the materials in a particular serialized assembly or subassembly by a procured lot number.

This identification shall remain with the material at all times to provide complete traceability and certification information from the procurement source.

3.4 HANDLING AND STORAGE

The filters shall be stored in cabinets or containers purged with high purity dry nitrogen. Precautions must be taken to minimize the exposure of the filters to humidity levels greater than 30% relative humidity during handling, testing, and installation. The filters shall not be exposed to temperatures outside the range of -10 to 32°C during handling and storage. Appropriate procedures shall be followed during handling to insure that the filters will not be damaged or contaminated (per JPL Spec FS515279A).

3.5 ANOMALY REPORTING AND CORRECTIVE ACTION

The contractor shall notify JPL of any manufacturing failures or anomalies that place the timely delivery of filters at risk. The vendor shall contact and consult with the JPL cognizant engineer in order to plan and authorize corrective action.

4 DELIVERY

A JPL courier will receive the completed hardware and associated test reports at the contractor's facilities upon completion. The JPL courier will hand carry and deliver the hardware to JPL in a JPL-supplied shipping container purged with high-purity dry nitrogen.

APPENDIX A – WFC3 UVIS FILTER SPECTRAL SPECIFICATIONS

											Out of band	Minimum Average T λ_{-90} : λ_{+90}	
Fnumber	Fname	Description	λ_0	FWHM	λ_{-01}	λ_{-50}	λ_{-90}	λ_{+90}	λ_{+50}	λ_{+01}	max T @ λ		
* determined by color glass characteristics [] special and/or difficult requirements				All wavelengths in this table are in Ångstrom units									
BROAD BAND													
UVIS-1	F218W	ISM feature	2175	300		2025			2325		10^{-3}	2750	0.20
											10^{-4}	3250	
											10^{-5}	4000	
UVIS-2	F225W		2250	500		2000			2500		10^{-3}	2750	0.20
											10^{-4}	3250	
											10^{-5}	4000	
UVIS 3	F275W		2750	500		2500			3000		10^{-3}	3250	0.20
											10^{-4}	3750	
											10^{-5}	4500	
UVIS 4	F336W	U, Stromgren u	3375	550	*UG11	3100	*UG11	3610	3650	3725	10^{-4}	4000	0.45
UVIS 5	F390W	Washington C				3400			4400		10^{-4}	5000	0.55
UVIS 6	F438W	WFPC2 B	4320	695	3915	3970	4040	4595	4665	4755	10^{-4}	5300	0.65
UVIS 7	F555W	WFPC2 V	5410	1605	4340	4570	*GG455	*BG38	6175	6945	10^{-4}	8000	0.90
UVIS 8	F606W	WFPC2 Wide V	5956	2340	4590	4785	4925	7020	7125	7340	10^{-4}	8500	0.90
UVIS 9	F814W	WFPC2 Wide I	8353	2555	6865	7060	7235	9295	9615	10225	10^{-3}	11000	0.95
UVIS 10	F475W	SDSS g	4750	1520	3915	4000	4442	5465	5520	5630	5×10^{-5}	6500	0.90
UVIS 11	F625W	SDSS r	6250	1550	5390	5500	5555	6980	7050	7190	5×10^{-5}	8000	0.90

(continued)

APPENDIX A – WFC3 UVIS FILTER SPECTRAL SPECIFICATIONS (*cont'd*)

Fnumber	Fname	Description	λ_0	FWHM	λ_{-01}	λ_{-50}	λ_{-90}	λ_{+90}	λ_{+50}	λ_{+01}	Out of band		Minimum
											max T @ λ		Average T
* determined by color glass characteristics [] special and/or difficult requirements			All wavelengths in this table are in Ångstrom units										
BROAD BAND <i>cont'd</i>													
UVIS 12	F775W	SDSS i	7760	1470	6890	7030	7100	8415	8500	8670	50 ⁻⁵	9500	0.90
UVIS 13	F850W	SDSS z	—	—	*RG830	8320	*RG830	—	—	—	—	—	0.95
VERY BROAD BAND													
UVIS-14	F350LP		—	—	*GG375	3500	*GG375	—	—	—	—	—	0.95
UVIS-15	F300X		[short as technology allows]						3650		10 ⁻⁴	4300	0.50
UVIS 16	F475X					3800			6000		10 ⁻⁴	8000	0.80
UVIS 17	F600LP		—	—	*RG610	6000	*RG610	—	—	—	—	—	0.95
MEDIUM BAND													
UVIS 18	F390M		3900	200		3800			4000		5×10 ⁻⁵	4600	0.70
UVIS 19	F410M	Stromgren v	4105	190	3930	4010	4040	4170	4200	4300	5×10 ⁻⁵	4800	0.75
UVIS 20	F467M	Stromgren b	4675	230	4475	4560	4590	4755	4790	4890	5×10 ⁻⁵	5300	0.80
UVIS 21	F547M	Stromgren y	5475	710	[5007]	5120	5235	5710	5830	6000	5×10 ⁻⁵	6800	0.80
[T< 0.1 @ 5876]													
UVIS 22	F621M	11%	6212	640		5900			6540		5×10 ⁻⁵	7300	0.85
UVIS 23	F689M	11%	6886	710		6540			7250		5×10 ⁻⁵	8000	0.85
UVIS 24	F763M	11%	7630	780		7250			8030		5×10 ⁻⁵	8800	0.85
UVIS 25	F845M	11%	8454	870		8030			8900		5×10 ⁻⁵	9600	0.85

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APPENDIX A – WFC3 UVIS FILTER SPECTRAL SPECIFICATIONS (*cont'd*)

Fnumber	Fname	Description	λ_0	FWHM	λ_{-01}	λ_{-50}	λ_{-90}	λ_{+90}	λ_{+50}	λ_{+01}	Out of band	Minimum	
											max T @ λ	Average T λ_{-90} : λ_{+90}	
* determined by color glass characteristics [] special and/or difficult requirements				All wavelengths in this table are in Ångstrom units									
NARROW BAND													
UVIS 26	F280N	MgII 2795/2802?	2798	42		2777			2819		10 ⁻⁴ 10 ⁻⁵	4000 7000	0.05 0.05
UVIS 27	F343N	[NeV] 3426	3426	228	3198		3312	3540		3654	10 ⁻⁶	4000	0.30
UVIS 28	F373N	[OII] 3726/29	3732	38	3694		3713	3751		3770	10 ⁻⁶	4100	0.40
UVIS 29	F393N	CaII K	3934	40	3894		3914	3954		3974	10 ⁻⁶	4400	0.45
UVIS 30	F469N	HeII 4686	4686	32	4654		4670	4702		4718	10 ⁻⁶	5100	0.55
UVIS 31	F487N	H-β 4861	4867	45	4823		4845	4890		4912	10 ⁻⁶	5400	0.60
UVIS 32	F502N	[OIII] 5007	5013	47	4967		4990	5037		5060	10 ⁻⁶	5500	0.70
UVIS 33	F588N	HeI 5876 +NaI 5890/96	5886	60	5826		5856	5916		5846	10 ⁻⁶	6200	0.80
UVIS 34	F631N	[OI] 6300 +[SIII] 6312	6306	54	6252		6279	6333		[6352]	10 ⁻⁶	6900	0.80
UVIS 35	F645N	Continuum	6455	82	6374	6414			6496	6537	5×10 ⁻⁶	7000	0.80
UVIS 36	F656N	H-α 6563	6563	14	[6553]		6556	6570		[6576]	10 ⁻⁶	7000	0.80
UVIS 37	F658N	[NII] 6583	6585	20	[T< 0.001@6570]		6576	6596		6606	10 ⁻⁶	7000	0.80
UVIS 38	F665N	z (Hα+[NII]) & continuum	6654		[6594]		6607	6701		[6706]	10 ⁻⁶	7100	0.80

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APPENDIX A – WFC3 UVIS FILTER SPECTRAL SPECIFICATIONS (*cont'd*)

Fnumber	Fname	Description	λ_0	FWHM	λ_{-01}	λ_{-50}	λ_{-90}	λ_{+90}	λ_{+50}	λ_{+01}	Out of band	Minimum	
											max T @ λ	Average T $\lambda_{-90}; \lambda_{+90}$	
* determined by color glass characteristics [] special and/or difficult requirements			All wavelengths in this table are in Ångstrom units										
NARROW BAND <i>cont'd</i>													
UVIS 39	F673N	[SII] 6717, 31 & z (H α + [NII])	6731		[6689]		6694	6771		6800	10 ⁻⁶	7200	0.80
UVIS 40	F680N	z (H α + [NII]) & continuum	6902		[6742]		6756	7044		[7053]	10 ⁻⁶	7500	0.80
UVIS 41	F953N	[SIII] 9532	9532		9468		9500	9564		9596	5×10 ⁻⁶	9800	0.80
NARROW BAND QUAD ELEMENTS													
UVIS 42a	F191N	CIII] 1909	1909	30		1894			1924		10 ⁻⁴	4000	0.05
											10 ⁻⁵	7000	
UVIS 42b	F232N	CII] 2326	2326	36		2308			2344		10 ⁻⁴	4000	0.08
											10 ⁻⁵	7000	
UVIS 42c	F243N	[NeIV] 2425	2425	36		2407			2443		10 ⁻⁴	4000	0.08
											10 ⁻⁵	7000	
UVIS 42d	F379N	z ([OII] 3727)	3788	76	3712		3750	3826		3864	10 ⁻⁶	4100	0.40
UVIS 43a	F387N	[NeIII] 3869	3869	26	3843		3856	3882		3895	10 ⁻⁶	4400	0.45
UVIS 43b	F422M	continuum	4220	108	4116	4166			4274	4326	5×10 ⁻⁶	4800	0.50
UVIS 43c	F437N	[OIII] 4363	4364	30	4333		4348	4378		4393	10 ⁻⁶	4900	0.50
UVIS 43d	F493N	z (H- β)	4929	78	4851		4890	4968		5007	10 ⁻⁶	5400	0.60
UVIS 44a	F509N	z ([OIII] 5007)	5087	100	4887		5037	5137		5187	10 ⁻⁶	5500	0.70

(continued)

APPENDIX A – WFC3 UVIS FILTER SPECTRAL SPECIFICATIONS (*cont'd*)

Fnumber	Fname	Description	λ_0	FWHM	λ_{-01}	λ_{-50}	λ_{-90}	λ_{+90}	λ_{+50}	λ_{+01}	Out of band	Minimum
											max T @ λ	Average T λ_{-90} : λ_{+90}
* determined by color glass characteristics [] special and/or difficult requirements			All wavelengths in this table are in Ångstrom units									
NARROW BAND QUAD ELEMENTS <i>cont'd</i>												
UVIS 44b	F575N	[NII] 5755	5755	12	5737		5749	5761		5773	10 ⁻⁶	6100 0.70
UVIS 44c	F672N	[SII] 6717	6716	14	6703		6710	6724		[6731]	10 ⁻⁶	6900 0.70
UVIS 44d	F674N	[SII] 6731	6731	14	[6717]		6724	6738		6745	10 ⁻⁶	6900 0.70
UVIS 45a	CH4A	25/km-agt	8890	89		8845			8935		5×10 ⁻⁶	9300 0.80
UVIS 45b	CH4A	2.5/km-agt	9060	91		9015			9105		5×10 ⁻⁶	9400 0.80
UVIS 45c	CH4A	0.25/km-agt	9240	92		9194			9286		5×10 ⁻⁶	9600 0.80
UVIS 45d	CH4A	0.025/km-agt	9370	94		9323			9417		5×1 ⁻⁶	9800 0.80
UVIS 46a	CH4B	CH4 6194	6194	62		6163			6225		10 ⁻⁶	6700 0.80
UVIS 46b	CH4B	6194 cont.+	6340	63		6308			6372			0.75
		+6194 cont.- [dual passband filter]	6038	60		6008			6068		10 ⁻⁶	6800 0.75
UVIS 46c	CH4B	CH4 7270	7270	73		7234			7306		10 ⁻⁶	7700 0.80
UVIS 46d	CH4B	7270 cont.	7504	75		7466			7542		10 ⁻⁶	7900 0.80
SPECIALTY												
UVIS 47	P200	UV prism					R~100					
UVIS 48	COMP	Focus compensator for dichroic–IR simultaneous imaging										

APPENDIX B – OPTICAL FILTER ACCEPTANCE TEST MATRIX

PARAGRAPH	ACCEPTANCE TESTS	TEST ON WITNESS SAMPLE	TEST ON EACH DELIVERED FILTER
APPENDIX A	SPECTRAL CHARACTERISTICS		
2.5 – B, C, D, F	Wavelength Range		JPL Cary 5
2.5 – E	FWHM Passband Shape		JPL Cary 5
2.5 – G	Minimum Average Transmission		JPL Cary 5
2.5.4	Transmission Ripple Across Passband		JPL Cary 5
2.5.1 and 2.5.2	Out-of Band-Rejection		JPL Cary 5 with Modification
Drawing 10195732 Note 11	Transmission Wavefront (single filter substrate)		JPL BAT and TUT (GFSC)
Drawing 10195732 Note 4	Transmission Wavefront (laminated filter substrate)		JPL BAT and TUT (GFSC)
2.6.3	Focus Shift		JPL Focus Shift Setup
2.4	Index of Refraction	FIRM (GFSC)	
2.7.6	Birefringence	Vendor	
	MECHANICAL		
2.6	Dimension		JPL Optical Micrometer
2.6.3	Filter Thickness		JPL Optical Micrometer
2.6.2	Clear Aperture		JPL Optical Micrometer
2.6.4	Wedge		JPL BAT
2.7.1	Surface Figure	Vendor	JPL ZYGO Setup
	FABRICATION		
Drawing 10195732 Note 5	Scratch-Dig		JPL (10× microscope)
2.7.4	Coating Defects, Delaminations and Pinholes		JPL (10× microscope)
Drawing 10195732 Note 6	Surface Roughness		JPL (WYKO 3D Profilometer)
2.7.4.1	Coating Adhesion	Vendor	
2.7.4.2	Coating Hardness	Vendor	
	ENVIRONMENTAL		
2.7.4.4	Humidity	Vendor	
	Thermal Vacuum		JPL TV Facilities

APPENDIX C – FILTERS SUBSTRATE MATERIALS, INDEX, THICKNESS SUMMARY

The substrate material, thickness and index of refraction will be filled by the vendor in the marked spaces.

When filling this table use the format of **UVIS-1** for a monolithic filter construction and **UVIS-2** for a laminated sandwich filter construction.

The total thickness tolerance of ± 0.1 mm is defined as the sum of all the elements used in the construction of a single substrate.

EXAMPLE OF FORM USAGE						
UVIS 1X	FxxxW	Drawing #				
			Substrate	Thickness of Substrate	Index of Substrate	
UVIS 2X	FxxxW	Drawing #	Substrate A	Thickness of Substrate A	Index of Substrate A	
			Cement	Thickness of Cement	Index of cement	
		Drawing #	Substrate B	Thickness of Substrate B	Index of Substrate B	

UVIS Filter List

Filter #	Filter Name UVIS (ID)	Substrate Drawing #	Substrate Material	Thickness ± 0.1 mm (± 0.1 mm total tolerance per filter)	Index of Refraction	Radius (m)
BROAD BAND						
UVIS 1	F220W	10195731				
UVIS 2	F265W	10195731				
UVIS 3	F315W	10195731				
UVIS 4	F336W	10195731				
UVIS 5	F390W	10195731				

(continued)

APPENDIX C – FILTERS SUBSTRATE MATERIALS, INDEX, THICKNESS SUMMARY (cont'd)

Filter #	Filter Name UVIS (ID)	Substrate Drawing #	Substrate Material	Thickness $\pm 0.1\text{ mm}$ ($\pm 0.1\text{ mm}$ total tolerance per filter)	Index of Refraction	Radius (m)
BROAD BAND <i>cont'd</i>						
UVIS 6	F438W	10195731				
UVIS 7	F555W	10195731				
UVIS 8	F606W	10195731				
UVIS 9	F814W	10195731				
UVIS 10	F475W	10195731				
UVIS 11	F625W	101957310				
UVIS 12	F775W	10195731				
UVIS 13	F850W	10195731				
VERY BROAD BAND						
UVIS 14	F350LP	10195731				
UVIS 15	F300X	10195731				

(continued)

APPENDIX C – FILTERS SUBSTRATE MATERIALS, INDEX, THICKNESS SUMMARY (cont'd)

Filter #	Filter Name UVIS (ID)	Substrate Drawing #	Substrate Material	Thickness $\pm 0.1\text{ mm}$ ($\pm 0.1\text{ mm}$ total tolerance per filter)	Index of Refraction	Radius (m)
VERY BROAD BAND <i>cont'd</i>						
UVIS 16	F475X	10195731				
UVIS 17	F600LP	10195731				
MEDIUM BAND						
UVIS 18	F390M	10195731				
UVIS 19	F410M	10195731				
UVIS 20	F467M	10195731				
UVIS 21	F547M	10195731				
UVIS 22	F660M	10195731				
UVIS 23	F710M	10195731				
UVIS 24	F780M	10195731				
UVIS 25	F850M	10195731				

(continued)

APPENDIX C – FILTERS SUBSTRATE MATERIALS, INDEX, THICKNESS SUMMARY (cont'd)

Filter #	Filter Name UVIS (ID)	Substrate Drawing #	Substrate Material	Thickness ± 0.1 mm (± 0.1 mm total tolerance per filter)	Index of Refraction	Radius (m)
NARROW BAND						
UVIS 26	F280N	10195731				
UVIS 27	F243N	10195731				
UVIS 28	F375N	10195731				
UVIS 29	F393N	10195731				
UVIS 30	F469N	10195731				
UVIS 31	F487N	10195731				
UVIS 32	F502N	10195731				
UVIS 33	F588N	10195731				
UVIS 34	F631N	10195731				
UVIS 35	F645N	10195731				
UVIS 36	F656N	10195731				

(continued)

APPENDIX C – FILTERS SUBSTRATE MATERIALS, INDEX, THICKNESS SUMMARY (cont'd)

Filter #	Filter Name UVIS (ID)	Substrate Drawing #	Substrate Material	Thickness $\pm 0.1\text{ mm}$ ($\pm 0.1\text{ mm}$ total tolerance per filter)	Index of Refraction	Radius (m)
NARROW BAND <i>cont'd</i>						
UVIS 37	F658N	10195731				
UVIS 38	F665N	10195731				
UVIS 39	F673N	10195731				
UVIS 40	F680N	10195731				
UVIS 41	F953N	10195731				
QUAD FILTERS						
UVIS 42a	F191N	10195733				
UVIS 42b	F232N	10195733				
UVIS 42c	F243N	10195733				
UVIS 42d	F379N	10195733				
UVIS 43a	F378N	10195733				

(continued)

**APPENDIX C – FILTERS SUBSTRATE MATERIALS, INDEX, THICKNESS
SUMMARY (cont'd)**

Filter #	Filter Name UVIS (ID)	Substrate Drawing #	Substrate Material	Thickness ± 0.1 mm (± 0.1 mm total tolerance per filter)	Index of Refraction	Radius (m)
QUAD FILTERS cont'd						
UVIS 43b	F422M	10195733				
UVIS 43c	F437N	10195733				
UVIS 43d	F493N	10195733				
UVIS 44a	F509N	10195733				
UVIS 44b	F575N	10195733				
UVIS 44c	F672N	10195733				
UVIS 44d	F674N	10195733				
UVIS 45a	CH4A	10195733				
UVIS 45b	CH4A	10195733				
UVIS 45c	CH4A	10195733				
UVIS 45d	CH4A	10195733				

(continued)

**APPENDIX C – FILTERS SUBSTRATE MATERIALS, INDEX, THICKNESS
SUMMARY (cont'd)**

Filter #	Filter Name UVIS (ID)	Substrate Drawing #	Substrate Material	Thickness $\pm 0.1\text{ mm}$ ($\pm 0.1\text{ mm}$ total tolerance per filter)	Index of Refraction	Radius (m)
QUAD FILTERS <i>cont'd</i>						
UVIS 46a	CH4B	10195733				
UVIS 46b	CH4B	10195733				
UVIS 46c	CH4B	10195733				
UVIS 46d	CH4B	10195733				
SPECIAL FILTERS						
UVIS 47	P200	10195734				
UVIS 48	COMP	10195731				